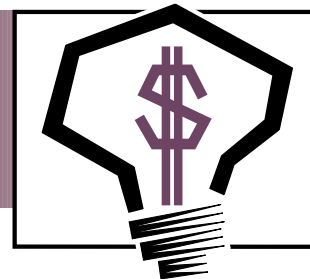


INVENTIONS & INNOVATION

Project Fact Sheet



A MINIATURE, INEXPENSIVE AMPEROMETRIC OXYGEN SENSOR

BENEFITS

- Could save 4 million Btu of natural gas per residential installation annually
- Could save 19.3 trillion Btu annually by 2010
- Senses up to 100% oxygen
- Operates independent of temperature
- Shows excellent repeatability to changes in oxygen partial pressure
- Has small size and mass, with fast warm-up time
- Can be inexpensively manufactured in large volumes, using well-established methods and facilities.

APPLICATIONS

The new sensor has three major markets: small boiler combustion control, safety diagnostics for breathing oxygen, and automotive applications. Two versions have been developed: a Broad-Range Sensor for applications that require up to 100% oxygen sensing and a Combustion Sensor for applications that operate at very low oxygen levels (for fabrication purposes, these sensors differ only in their sintering temperatures). The sensors' developers have attracted enthusiastic industrial partners in each of these market segments.

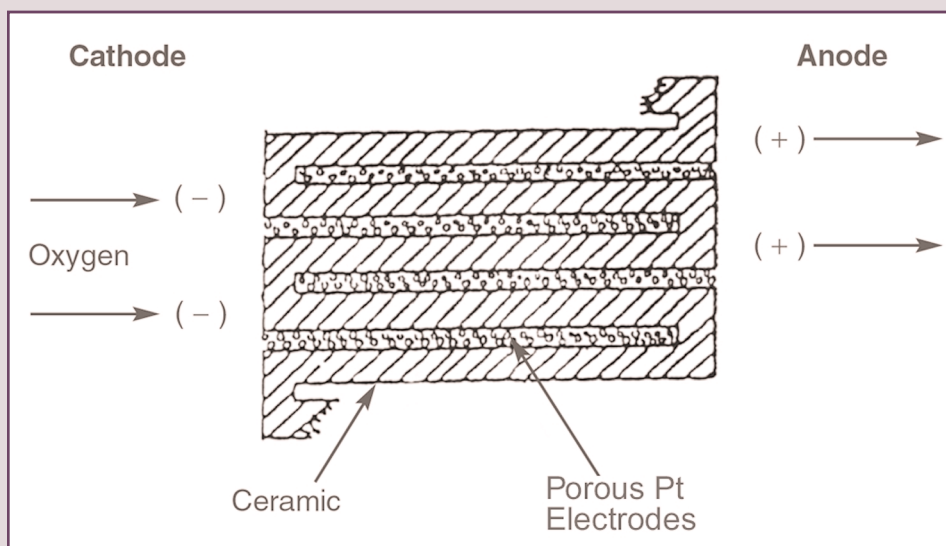
MINIATURE OXYGEN SENSOR COSTS SIGNIFICANTLY LESS THAN CONVENTIONAL SENSORS

Combustion systems are an integral part of industrial and commercial plants and processes. To maintain optimum fuel efficiency a boiler system's combustion by-products must be analyzed. The oxygen partial pressure derived from the boiler exhaust gas is measured by oxygen sensors, which have been available since the early 1970s. This allows the air-to-fuel ratio to be optimized, thus lowering energy consumption.

However, current oxygen sensor technology has limitations. Zirconia sensors, though accurate and reliable, are expensive. Their use is justified in large industrial applications but not in smaller industrial or commercial applications. Also, some less expensive sensors are unreliable.

In contrast, CeramPhysics' miniature, inexpensive amperometric oxygen sensor was designed to overcome cost and reliability problems. With a target manufactured price of \$2 each, this new technology would be the least expensive oxygen sensor on the market.

MULTILAYER CERAMIC CAPACITOR



CeramPhysics' amperometric oxygen sensor is a multilayer ceramic capacitor, which is ideal for inexpensive mass production and allows the sensor to be miniaturized.



Project Description

Goal: Manufacture broad-range and combustion oxygen sensors suited to a wide variety of industrial and commercial applications.

CeramPhysics has developed a new oxygen sensor that has a multilayer, ceramic-capacitor structure consisting of ceramic-zirconia layers separated by porous platinum electrodes. When voltage is applied to the electrodes, oxygen is pumped from the cathode to the anode through the ceramic layers. This amperometric pumping current measures the oxygen partial pressure in the surrounding gas. The tortuous diffusion paths through the porous platinum electrodes provide the diffusion limitation for amperometric oxygen sensing.

The sensor is manufactured as a multilayer ceramic capacitor. An important advantage of this method is that a platinum track can be incorporated in the cover plates of the sensor body. This embedded platinum track serves as both a heater and a thermometer. The design creates an integrated sensor with decreased resistance and increased amperometric current at constant voltage.

CeramPhysics, Inc., is developing this new technology with the help of a grant funded by the Inventions and Innovation Program in the U.S. Department of Energy's Office of Industrial Technologies.

Progress and Milestones

- Determine the optimum method for self-heating the sensor body.
- Redesign the microprocessors for sensing voltage and temperature control to incorporate improvements.
- Determine long-term stability of the sensors.
- Supply sensors and microprocessors to industrial partners for packaging and in-house testing.
- Create a final commercialization strategy based on the results of these steps.
- A patent pertaining to the new sensor has been issued to CeramPhysics, Inc., and a second patent is pending.

Economics and Commercial Potential

A market assessment for the new sensor concluded that because of a lack of competition, the small boiler market may be the best first entry. Increased burner efficiency through oxygen sensing will benefit small boiler users by decreasing emissions of carbon monoxide, carbon dioxide, and nitrous oxides as well as unburned fuel, which reacts with other atmospheric pollutants. Another likely market is the automotive industry, which must add a true oxygen sensor behind the catalytic converter. A small, low-cost, easily packaged instrument will be attractive for this application.

Fossil fuels are so inexpensive in the United States that current combustion-diagnostic systems cannot be justified on the smaller burners used for commercial and residential space heating systems that consume a large percentage of these fuels. The low-cost sensor will provide economically justifiable combustion diagnostics to such burners for the first time. If the sensor increases combustion efficiency by just 5%, the savings would be 4.0 million Btu of natural gas per year for a residence. First sales of the technology are expected by 2003. Based on 6% market penetration by 2010, annual savings could be 19.3 trillion Btu with 3 million units installed. Market penetration of 30% by 2020 could save 46.9 trillion Btu annually from the operation of 9 million units.

The safety-diagnostics market is driven by the need to sense nearly 100% pure oxygen. The sector of immediate interest, the U.S. home health care market, has sales of 500,000 new units of oxygen concentrators per year, and the FDA requires an oxygen monitor on each unit. Because of its unique features, the new sensor is expected to gain rapid entry to this highly competitive market.



The Inventions and Innovation Program works with inventors of energy-related technologies to establish technical performance and conduct early development. Ideas that have significant energy savings impact and market potential are chosen for financial assistance through a competitive solicitation process. Technical guidance and commercialization support are also extended to successful applicants.

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Order# I-OT-818
September 2001